Interim Findings: Review of Analysis of GHG Mitigation Measures

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Presentation Overview

- Presentation of “big picture” analytical results
- Review of sector analyses conducted to date

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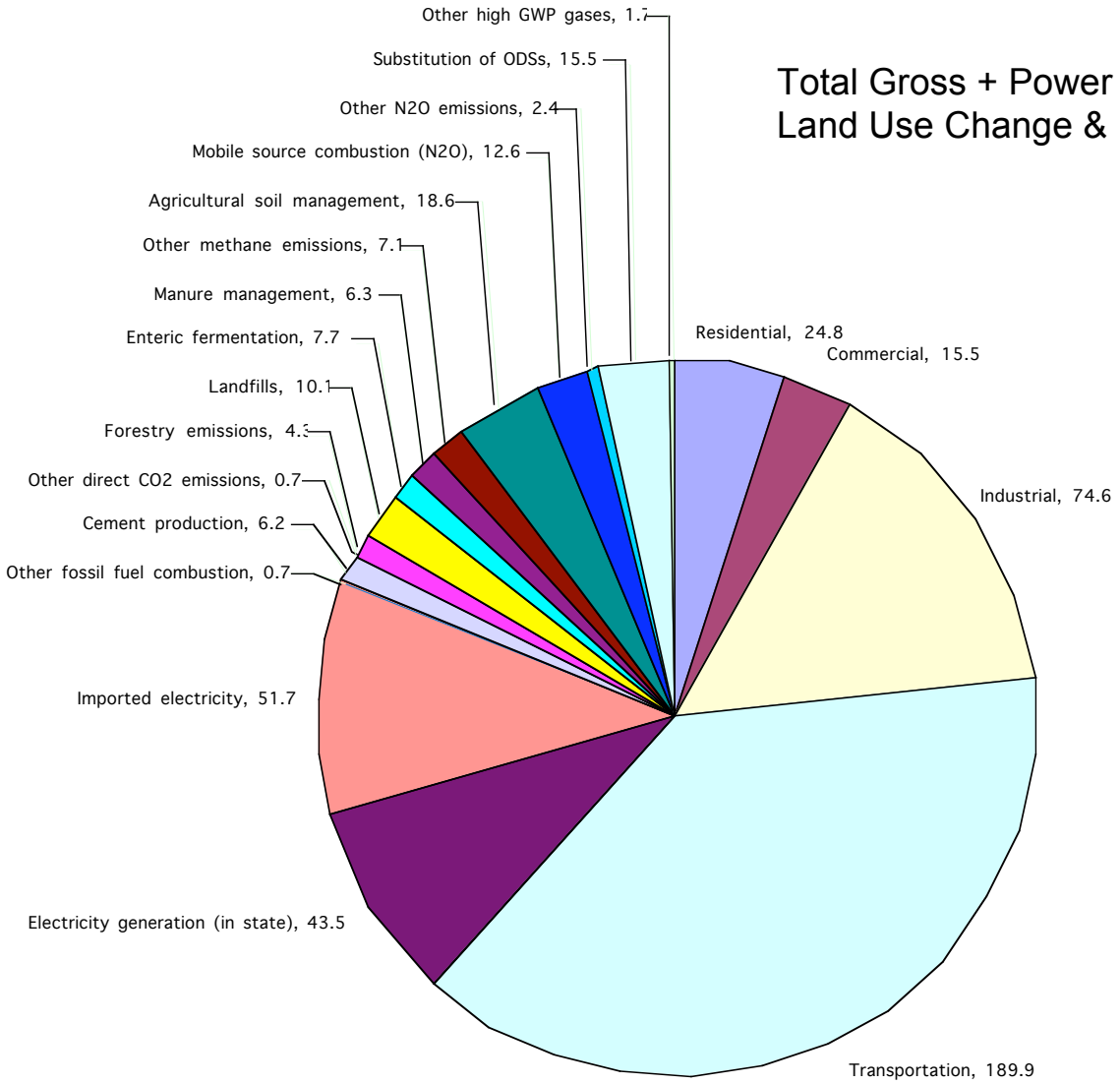
California 2002 GHG Emissions Inventory



Total Gross + Power Imports = 493.9
Land Use Change & Forestry Sinks = -20.3

Overview of Analytical Results To Date (1)

- CCAP evaluated measures in the transportation, cement and sinks (forestry and agriculture) sectors.
- ICF Consulting evaluated measures to reduce high GWP gases in the landfill, natural gas, semiconductor and dairy sectors, among others.
- Measures identified thus far are projected to reduce GHG emissions by 36 $MMTCO_2e$ in 2010 and 117 MMTCO2 in 2020.
- These measures are additional to strategies already underway in California that are estimated to reduce GHGs by 23 $MMTCO_2e$ in 2010 and 70 MMTCO2 in 2020.
- Power sector and refinery options would be expected to increase the total reduction potential by roughly 15* and 2** $MMTCO_2e$ in 2010, respectively, and by 26* and 6** $MMTCO_2e$ in 2020.***

* Power sector reductions assume a cap set 2000 levels after subtracting out reduction that are credited to the accelerated RPS (33% by 2020)..
** Refinery reductions assume stabilization at 2005 levels.
*** Both estimates assume preliminary CCAP baseline projections. Baselines for both sectors will change once plant-specific refining data and the power sector modeling study are available. We do not know how the costs of these reductions compare with options available to other sectors.

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Summary of Emissions Reductions by Sector

Total GHG Reduction Potential (MMTCO2e)

Sector	2010 CCAP/ICF	2020 CCAP/ICF
Transportation	8.3	65.4
Power	TBD	TBD
Agriculture/Forestry	12.5	18.0
Methane	15.6	16.7
PFC	3.1	7.1
HFC	0.9	6.2
Cement	2.2	2.4
SF6	1.2	1.5
Oil Refining	TBD	TBD
ALL	43.8	117.4

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Strategies Already Underway in CA

Lead Agency/Strategy	GHG Savings [1] (Million Tons CO_2 Equivalent) 2010	2020
Air Resources Board		
GHG Vehicle Standards (AB 1493)	1	30
Diesel Anti -idling	1	2
Energy Commission /Public Utilities Commission		
Accelerated Renewable Portfolio Std (33% by 2020)	5	11
Million Solar Roofs	0.4	3
Integrated Waste Management Board		
Zero Waste/High Recycling Programs	7	10
Energy Commission		
Full cost -effective natural gas efficiency im provements	1	6
Appliance Efficiency Standards [2]	3	5
Fuel-efficient Replacement Tires & Inflation Programs	3	3
Business Transportation and Housing		
Reduced Venting and Leaks in Oil and Gas Systems	1	1
State and Consumer Services		
Green Buildings Initiative	Not yet estimated	
Air Resources Board/C alEPA		
Hydrogen Vehicles	Not yet estimated	
Total Potential Emission Reductions [3]	**23**	**70**

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Comparison with Alternative Targets

	2010	2020
CEC estimated baseline emissions (very preliminary)* with adjustments** in 2020	538	575-590
2000 emissions (gross CA emissions w/imported electricity)	489	489
difference	49	86-101
1990 emissions (gross CA emissions w/imported electricity)	439	439
difference	98	136-151
CCAP/ICF measures	36	117
Strategies already underway in CA	23	70
Total mitigation measures	59	187
Hypothical additional reductions from power/refining (stabilize at 2000/current levels)	17	32

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Notes on Previous Slide, Comparison with Alternative Targets

- CEC's baseline assumes a projected increase in gasoline demand and natural gas projections based on data prepared for the 2005 IEPR. Emissions from all other sectors, including out-of-state power, were assumed to remain constant at 2002 levels. Therefore, this baseline forecast likely underestimates emissions growth, especially in 2020.
- Additional growth in emissions was added to the 2020 time period to reflect growth in other sectors of the economy.
- Power sector emissions are stabilized at 2000 levels and refining emissions are stabilized at 2005 levels. These estimates are based on CCAP BAU projections and are subject to change. Additional analysis is needed to calculate the costs of these reductions.

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Overview of Analytical Results To Date (2)

- Cost-effectiveness ($/MTCO$_2$e) of new mitigation options identified by CCAP and ICF ranges from less than $0 (net cost savings) to over $1000/MTCO$_2$e for a few isolated measures in the transportation and natural gas sectors.

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Summary of Cost-Effectiveness of Measures Identified ($/MTCO$_2$e)

Cumulative GHG reductions from CCAP/ICF measures at each cost step, all sectors (approximate)		
Step	Reductions (MMTCO2e)	
	2010	2020
<0	7	10
<$10	22	25
<$20	27	31
<$30	29	38
<$50	29	63

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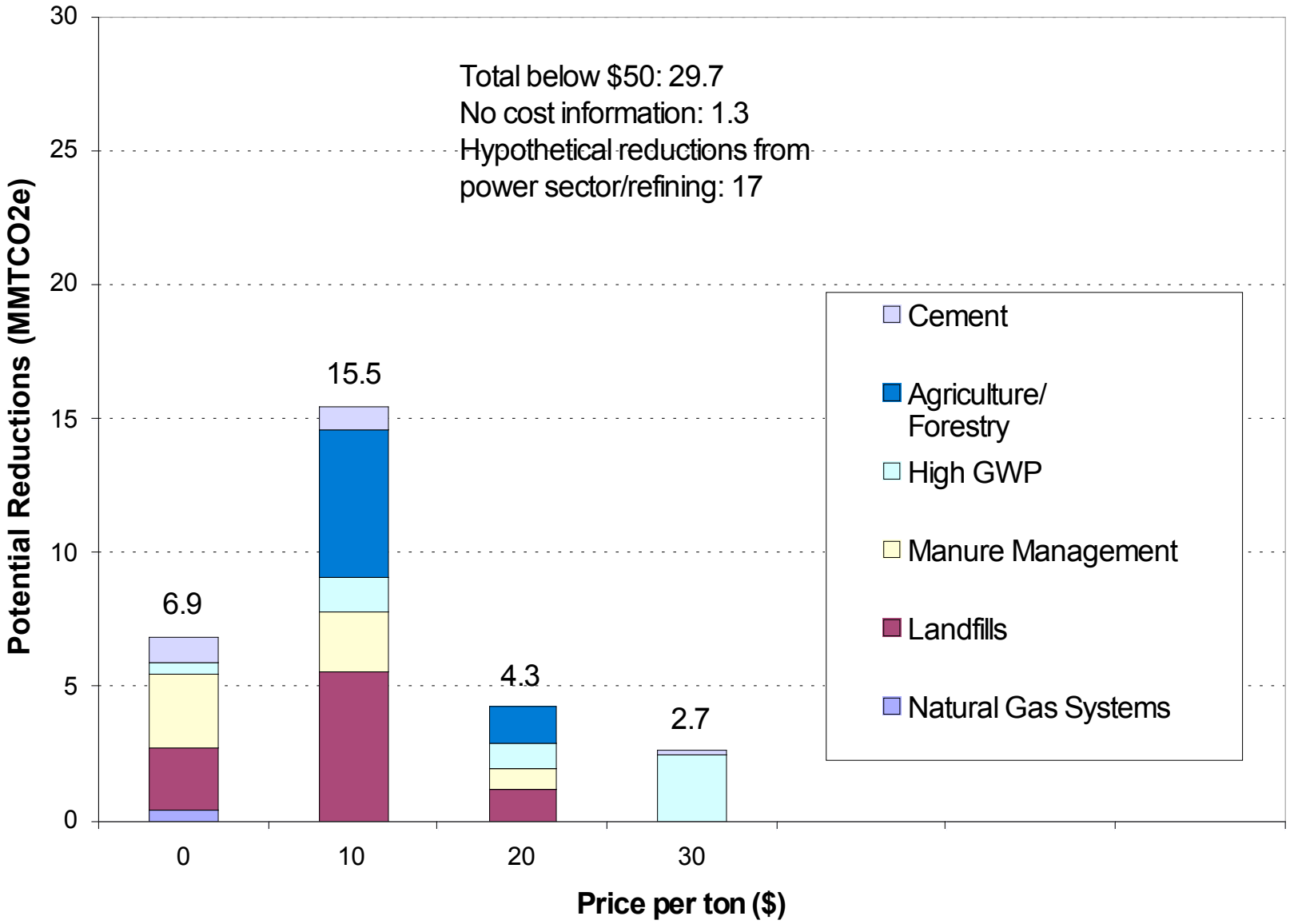
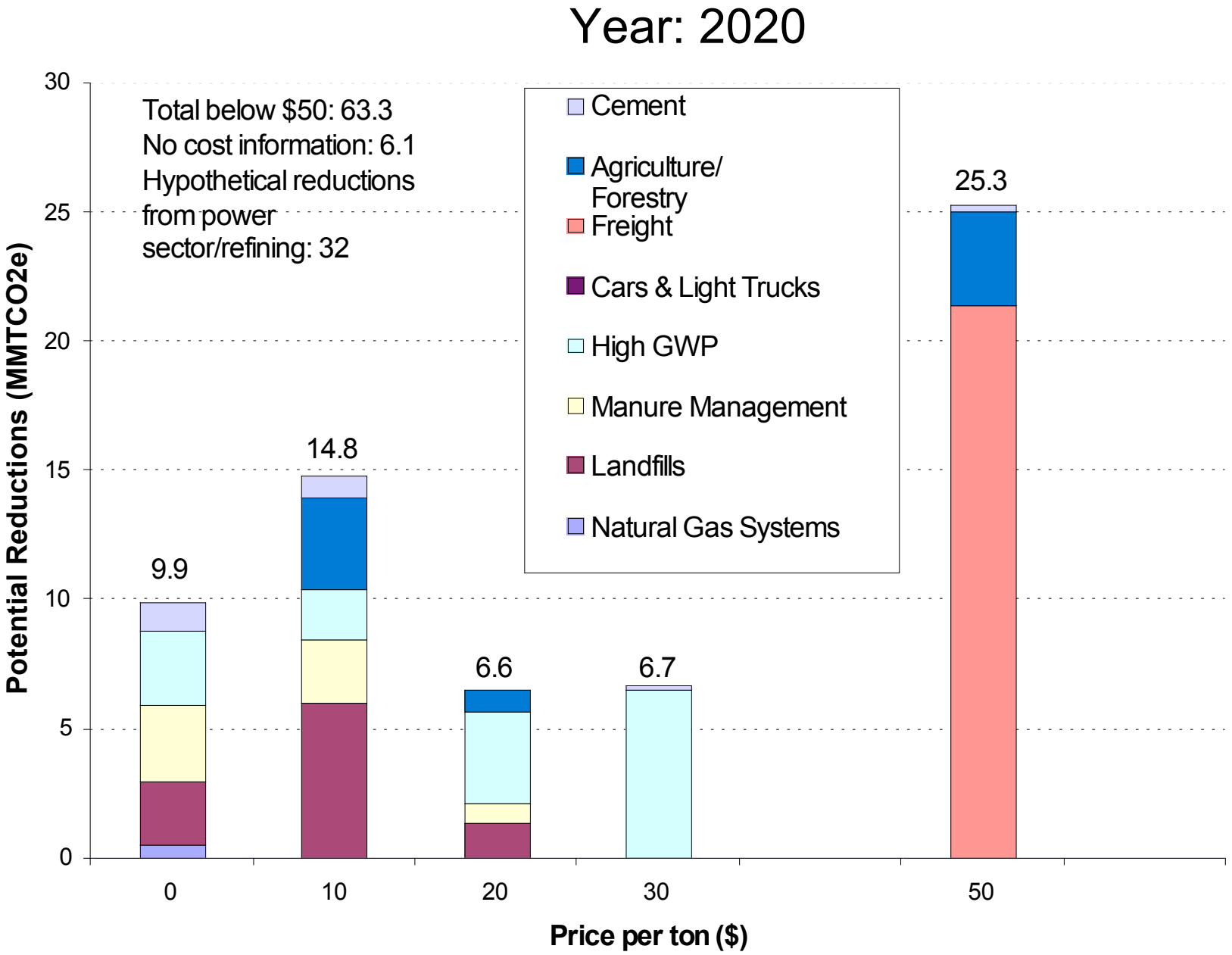
Year: 2010


Total below $50: 29.7
No cost information: 1.3
Hypothetical reductions from power sector/refining: 17
Potential Reductions (MMTCO2e)
30
25
20
15
10
5
0
6.9
15.5
4.3
2.7
0
10
20
30
Price per ton ($)
Cement
Agriculture/ Forestry
High GWP
Manure Management
Landfills
Natural Gas Systems


Year: 2020
Total below $50: 63.3
No cost information: 6.1
Hypothetical reductions from power sector/refining: 32
Cement
Agriculture/ Forestry
Freight
Cars & Light Trucks
High GWP
Manure Management
Landfills
Natural Gas Systems
9.9
14.8
6.6
6.7
25.3
Potential Reductions (MMTCO2e)
0
5
10
15
20
25
30
0
10
20
30
50
Price per ton ($)

Sectors Covered in CCAP/ICF Analysis

- Transportation
- Sinks (forestry and agriculture)
- Cement
- Landfills
- Dairy/Manure Management
- Natural Gas
- Semiconductor

- We are still evaluating costs of measures for the power sector.
- A bottom-up assessment of options in refining will be difficult due to insufficient data on in-state facilities and the effectiveness of specific control measures.

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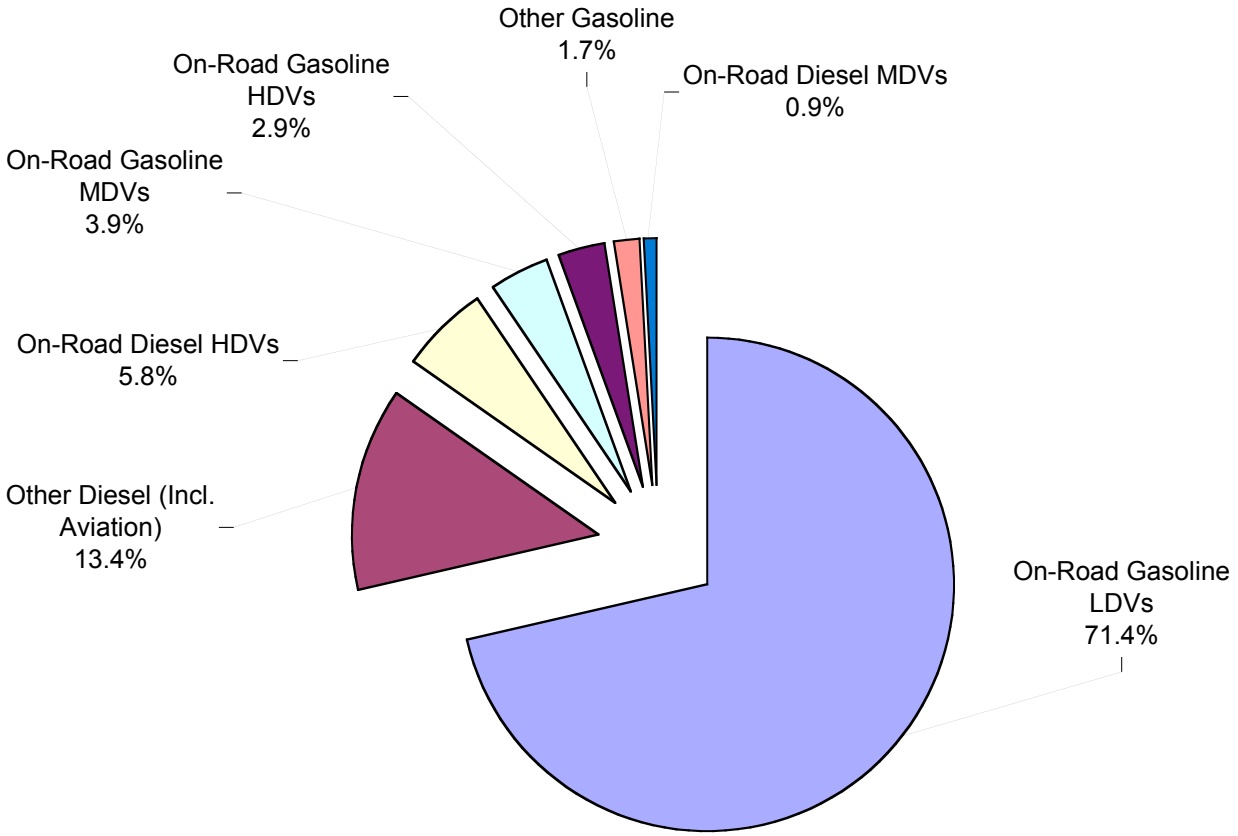
2002 CA Transportation GHG Emissions (by vehicle weight)



LDVs = Light Duty Vehicles (cars and trucks)
MDVs = Medium Duty Vehicles, cargo vans, delivery vehicles (up to 8500lbs GVW)
HDVs = Heavy Duty Vehicles, > 8500lbs
Source: California Energy Commission, 2004.

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Review of Transportation Measures

- Baseline annual CO_2 emissions increase from **190 $MMTCO_2$ in 2002** to **310 $MMTCO_2$ in 2020**
  - assumes 1.8% annual VMT growth
  - represents 41% of state GHGs (2002 CEC inventory)
- 2020 transport reductions = **65.4 $MMTCO_2$**.
- Pavley standards are projected to achieve **30 $MMTCO_2$** in 2020, 'advanced' Pavley could achieve more
- <u>Reductions from 3 core groupings</u>
  - Light duty vehicles (50% of savings)
  - Heavy duty vehicles & fuels (36% of savings)
  - Ports, aviation and rail (14% of savings)

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Summary of Transportation Sector GHG Reductions in California

Program or Policy	2010	2020	2020 $/MMTCO2e
	(MMTC02e)	(MMTC02e)	(millions)
CARS & LIGHT TRUCKS			
Corn & Cellulosic Ethanol (vehicles using 85% ethanol)	0.33	11.51	$43
Reduction in vehicle miles traveled (VMT)	0.5	5.49	TBD
H2, Plug-in Hybrids, CNG & LPG Light Duty Vehicles (LDVs)	0.25	2.44	$331 - $1923
CA Feebate Program	TBD	TBD	TBD
Pay As You Drive Insurance	TBD	TBD	TBD
Subtotal	**1.1**	**19.4**	
FREIGHT TRANSPORTATION			
Diesel HDVs (CNG, Efficiency, Hybrids) & Gasoline Medium Duty Hybrids	2.63	24.85	$49 - $309
Biodiesel and Synthetic Diesel Alternatives	0.55	9.85	$51
Subtotal	**3.2**	**34.7**	
PORTS, AIR & RAIL			
Aircraft Modifications, Operations and Weight Reduction	2.95	5.89	$144
Freight Rail (10% shift from truck)	0.66	3.77	$530
Port Electrification (forklifts, refrig trailers), Cold Ironing	0.38	1.06	$63 - $1429
High Speed Rail	0.00	0.53	TBD
Subtotal	**4.0**	**11.3**	
Total MMTCO2 potential savings	***8.3***	***65.4***	
% above CA 1990 Transport Baseline (1990 = 168 MMTCO2)	***62.2%***	***31.5%***	
Net 2020 MMTCO $_2$ (BAU 310)	*302*	*245*	

Source: CCAP based on 2005 IEPR and CEC analysis: ADDENDUM TO: OPTIONS TO REDUCE PETROLEUM FUEL USE IN SUPPORT OF THE 2005 INTEGRATED ENERGY POLICY REPORT (May 2005).
MMTCO2e = Million Metric Tons of Carbon Dioxide Equivalent

Next Steps for Analysis

- Ensure no double counting w/ Pavley
  - » Flex fuel vehicle, state fleet standards
  - » H_2 fuel cells, alternative ZEV compliance pathways
  - » Consider a GHG-based fuel standards program
  - » Review AQ implications for ethanol & biodiesel
- Potential options for further analysis
  - » Revise Passenger & Freight measures, as appropriate
  - » Also: Pay as You Drive Insurance, GHG-based feebates, fuel economy standards, VMT costs
- Consider development of an integrated policy framework

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Baseline Carbon Sequestration in CA

- Forests and soils achieved a net reduction of 9.5 $MMTCO_2e$ in 1999 (*Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*)*
- Carbon storage in wood products and landfilled waste increased 9.3 $MMTCO_2e$ that year, accounting for the net reduction.
- Altogether, carbon sequestration offset 4% of total state emissions in 1999.

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* Note: Does not include sequestration from landfills and products. The 2002 sequestration estimate is slightly higher than in 1999.

Options for Add'l Forest and Agricultural Carbon Storage

- Sequestration
  - Afforestation
  - Thinning to promote growth and burying harvested wood
  - Converting hardwood stands to conifer
  - Extending timber harvest rotations
  - Enhancing yard trees
  - Increasing use of no-till cropping
- Reducing Emissions
  - Thinning to promote forest growth with energy from biomass (displacing fossil fuel emissions)
  - Reducing clearing of forest land

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Activity	Number of Tons	Levelized Cost/Ton	Notes
Afforestation	3.5 MMTCO $_2$e per year, average over 80 years.	$6 to >$ 70 depending on land cost.	Few tons for 10 -20 years. Can reduce cost by thinning .
Forest health thins	3.7 MMTCO $_2$e per year, indefinitely.	<$10	
Landfill thinnings	9.5 MMTCO $_2$e per year, indefinitely.	$24 to $96	Cost depends on fiber pr ice.
Thin to Reduce Fire	None	Not Applicable	Appears to cause net emissions
Convert hardwood to conifer	Cumulative, 70 MMTCO $_2$e over 45+ years.	$10	No GHG benefit for 10-20 years
Extend rotations	0.7 MMTCO $_2$e per year for decades	$110-$140	No GHG benefit in first ten years
Reduce forest loss	0.9 MMTCO $_2$e per year for decades	< $20?	Implemented via development rules
Enhance yard trees	< 0.1 MMTCO $_2$e per year?	Uncertain	Also reduces cooling demand
Increase no -till	3.8 MMTCO $_2$e per year for 15 years	< $5 if b y education $100 if rental payments reqired	

Estimated Additional Sequestration from Evaluated Measures

- If these measures were all used, California could achieve an additional 12.5 MMTCO2e of carbon sequestration in 2010 and 18 MMTCO2e of carbon sequestration in 2020.

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Magnitude of Potential Sinks Benefits

- Carbon sequestration estimates are for the prices estimated here
- At higher prices, substantially more tons of carbon might be sequestered.
- Biologically, it is possible to achieve much more sequestration than estimated here but the total biological potential will not be achieved because:
  - Forest management will not be applied in reserves
  - Some locations are too far from roads or too steep to be treated efficiently
  - Risks to other values are too high at some locations, such as risks of erosion or damage to habitat of an endangered species

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Baseline Cement Emissions in CA

- Baseline annual direct CO_2 emissions to increase from 10.4 to 15.1 $MMTCO_2$ from 2005 to 2025 (assuming 2% annual sector growth).
- Cumulative cement emissions during that time period are estimated at 263 MMTCO2.
- Baseline emissions are projected to be 11.3 MMTCO2 in 2010 and 13.6 MMTCO2 in 2020.
- 1% sector growth lowers the baseline by ~12% relative to the 2% growth scenario

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Potential Cumulative Reductions from the Cement Sector

- 47 MMTCO$_2$ in potential cumulative reductions from baseline
  - 38 MMTCO$_2$ from measures costing ≤$10/MT (7% discount)
  - 36 MMTCO$_2$ from measures costing ≤$5/MT (7% discount)
  - 20 MMTCO$_2$ from measures costing ≤$0/MT (7% discount)
  - Little effect at ≤$10/MT and ≤$5/MT by 4% and 20% discount rates
  - 1% sector growth lowers reductions by 5–10% relative to 2% growth.

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Most Cement Reductions from 3 Measures

- 70% of cumulative emissions reductions from 2 measures
  - Limestone Portland Cement: 12.6 MMTCO$_2$ at ($21)/MT (savings)
  - Blended Cement: 14.0 MMTCO$_2$ at $2.40/MT
- Possible 3.6-MMTCO$_2$ reduction from Waste Tire Fuel at ($14)/MT (savings), but dependent upon current waste-tire use
- All 3 measures have market barriers to implementation
  - Limestone Portland Cement: Market acceptance
  - Blended Cement: Cement standards
  - Waste Tire Fuel: Public resistance
- State policies need to address these market barriers to enable emissions reductions from CA cement sector

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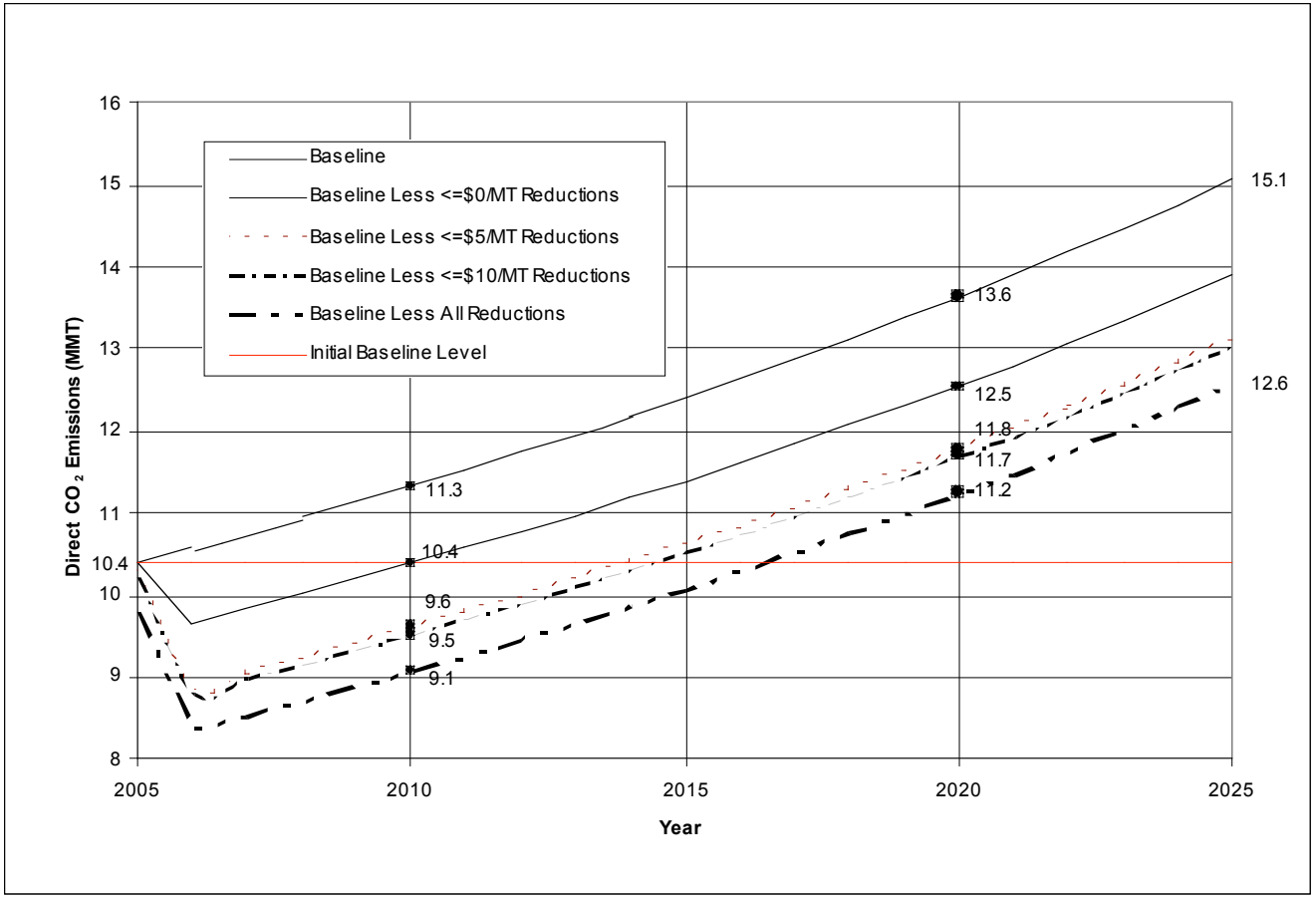
Projected Future Direct Emissions from CA Cement Sector (2% Annual Sector Growth)



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At best, annual emissions return to initial value by 2017 and exceed it by 2.2 MMTCO2 in 2025, reaching 12.6 MMTCO2

Landfills (1)

- Baseline emissions are projected to increase from 9.87 MMTCO2e in 2000 to 10.64 and 11.43 MMTCO2e in 2010 and 2020.
- Options evaluated include direct gas use projects (gas is collected and transported to an end user) and electricity projects (gas is collected and used to generate electricity) assuming different size landfills.
- Total reductions for this sector are estimated at 9.04 MMTCO2e in 2010 and 9.71 MMTCO2e in 2020.
- A total of 2.28 and 2.44 MMTCO2e are available in 2010 and 2020 for less than $0/MTCO2e; 7.81 and 8.39 MMTCO2e are available in 2010 and 2020 for less than $10/MTCO2e; and 9.04 and 9.71 MMTCO2e are available in 2010 and 2020 for less than $20/MTCO2e.
- In general, the direct gas use projects are more cost-effective than the electricity projects, and both types of projects are more cost-effective when applied to larger landfills.

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Source: ICF Consulting, 2005

Landfills (2)

- For larger landfills, the number and amount of waste are known with reasonable certainty.
  - » However, even at these sites, residual emissions not captured in the collection system may represent 25% of total emissions. There are little data on the fraction that oxidizes versus the fraction that is emitted as methane.
- Smaller landfills report on a voluntary basis, so the dataset may not be complete.
  - » In particular, data on waste in place for older landfills may be uncertain. Factors affecting the rates of decomposition and the timing and amount of CH4 generation are very site-specific and data may not be adequate.
- These data gaps suggest a need for more systematic reporting.

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Source: Klein, D., June 2005

Dairy/Manure Management

- Baseline emissions are projected to increase from 7.82 MMTCO2e in 2000 to 8.85 and 9.54 MMTCO2e in 2010 and 2020.
- Options evaluated include covered lagoons and various kinds of digesters applied to different size dairy farms.
- Total reductions for this sector are estimated at 5.82 MMTCE in 2010 and 6.24 MMTCE in 2020.
- A total of 2.79 and 2.99 MMTCO2e are available for less than $0/MTCO2e in 2010 and 2020; 5.07 and 5.44 MMTCO2e are available for less than $10/MTCO2e in 2010 and 2020; and the remaining tons are all available for less than $20/MTCO2e.
- The majority of reductions come from covering lagoons and collecting the CH4 emissions for energy use.

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Source: ICF Consulting, 2005

Natural Gas

- Baseline emissions are projected to increase from 1.81 MMTCO2e in 2000 to 2.00 and 2.19 MMTCO2e in 2010 and 2020.
- 22 separate options were evaluated. When ordered from low to high cost, no one measure reduces emissions by more than 5% of the baseline.
- Total reductions for this sector are estimated at 0.725 MMTCO2e in 2010 and 0.795 MMTCO2e in 2020.
- A total of 0.466 and 0.392 MMTCO2e are available for less than $0/MTCO2e in 2010 and 2020; 0.505 and 0.554 MMTCO2e are available for less than $20/MTCO2e; while additional reductions are more costly

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Source: ICF Consulting, 2005

Semiconductor

- Baseline emissions are projected to increase from 1.03 MMTCO2e in 2000 to 3.36 and 7.74 MMTCO2e in 2010 and 2020.
- Options evaluated include plasma abatement, remote clean, catalytic abatement, capture/recovery and thermal destruction.
- Total reductions for this sector are estimated at 3.10 MMTCE in 2010 and 7.14 MMTCE in 2020.
- The estimated cost of these options ranges from $12 to $30 per MTCO2e.
- The lowest cost measure ($12.86/MTCO2e), plasma abatement, reduces 0.72 MMTCO2e in 2010 and 1.65 MMTCO2e in 2020.
- One measure, remote clean, achieves over half the total reductions (1.64 MMTCO2e in 2010; 3.76 MMTCO2e in 2020).
- These reductions are roughly equal to the national commitment by the semiconductor industry to reduce emissions to 10% below 1995 levels

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Source: ICF Consulting, 2005

Conclusions

- Emissions reductions from multiple sectors are needed to meet emission reduction goals at 2000 or 1990 levels.
- Assuming reductions from the power and refining sectors, the State could meet its targets by focusing on measures that cost less than $\$10\text{-}20/MTCO_2e$ in 2010 while options could be more costly to meet the target in 2020.
- Further in-depth analysis of options would produce a more complete picture and technological innovation could lower costs significantly
- Some options currently face technical or policy barriers to implementation as well as political hurdles that could prevent full penetration of the lowest cost approaches.

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Update on Power Sector Analysis

- The Power Sector Workgroup has been developing assumptions for use in the NEMS model.
- An initial reference case was completed and is leading to refinement of some assumptions.
- Coding changes have been made to allow analysis of caps on emissions associated with power demand.
- The Power Sector Workgroup of the CCAC is meeting this Wednesday to review modeling assumptions.

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Update on Refining Analysis

- CCAP determined that data were insufficient to develop a reliable emissions baseline or to assess specific mitigation measures and costs for this sector.
- We are consulting with industry on process and policy options for overcoming data gaps and for achieving emissions reductions from this sector.
- We are likely to recommend a process to collect data from this sector.

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For Further Information

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- ICF Consulting, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, Draft, prepared for the California Energy Commission, June 2005.
- Klein, D., "Methane Assessment for California," Draft, prepared for the Center for Clean Air Policy, June 6, 2005.
- LBNL reports on the cement industry, located at http://ies.lbl.gov/iespubs/ieuapubs.html
- Smith, G. and S. Davis, "Activities and Policies to Enhance Forest and Agricultural Carbon Sinks in California," Draft, prepared for the Center for Clean Air Policy, June 27, 2005.

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